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Optimizing the groundwater monitoring network using MSN theory

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Abstract

The purpose of optimizing a groundwater monitoring network is to obtain sufficient hydrogeological information for the required precision using the fewest wells. This study describes three possible methods of optimization. The first method describes the hydrogeologic analysis way to optimize the monitoring network. The second way employs sampling theory, which primarily uses a variety of sampling techniques such as simple random sampling, systematic sampling, stratified sampling, and spatial stratified sampling for analysis followed by the creation of a series of sampling designs with different conditions and, finally, comparison of these designs with the current distribution to determine a more suitable design. The last method draws on the idea of the Mean of Surface with Non-homogeneity (MSN), which is a combination of the spatial stratified sampling and block Kriging methods, to exert unbiased and optimal results. In this study, these two methods were used for optimization of a groundwater monitoring network, and the results indicated that MSN was suitable for optimization based on the existing distribution, but that spatial sampling may be required to create an original monitoring network.
Hydrogeological analysis, in particular, is a qualitative method that basically involves synthetic factors (such as detailed meteorological indicators, physical environments, and human activities) that are clustered into zones and superimposed over the monitored area, whereas at least one well is required in each zone [1][3][4]. The method offers no quantitative standard to predefine the number of required wells and their layout.
The basic steps involved in sampling theory during optimization of the monitoring network are as follows:
The entire monitoring area is divided into many grids with a suitable resolution based on the actual conditions, and the total grids serve as the population, which is used later.
A sampling method is selected.
The relative sampling parameters are set, in which different methods have different parameters, and different parameters correspond to the different computing functions of sample size.
The sample size is computed.
The sampling points (wells) are distributed at random in the study area.
The sampling scheme is compared with the current distribution, and the final design is determined.
The basic steps involved in MSN during optimization of the monitoring network are as follows[2]:
The study area is stratified based on prior knowledge, with the part that cannot be placed in wells being placed in a single layer that will not be considered in the latter process;

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The half-variation function in view of the values of the current design are computed (not yet optimized), and the mean and standard deviation of block Kriging of the existing wells are determined, which can be used to evaluate the present groundwater monitoring network;
An expected precision (that is the standard deviation here) on the strength of the monitoring goals or other factors is set;
Randomly sampling based on the spatial stratification, block Kriging and the expected precision in the study area;
A random distribution design in which the expected standard deviation is less than the current one is generated, after which a design based on adding or decreasing wells is made.
These methods had been implied into optimizing the groundwater quality in Xinjiang Uighur Autonomous Region, China. Through comparison, hydrogeological analysis produced the greatest number of final designs, followed by MSN and then sampling. Although sampling produced the lowest number of designs, it had the largest standard deviation. Moreover, even distribution was displayed in each layer for MSN method (Fig.1), indicating that this method is good for optimizing the groundwater monitoring network. But in sampling process, the expected variance was only the sampling variance that was not included the original wells when sampling was conducted; therefore, the last standard deviation must be computed again, the distribution graph was showed as Fig.2.

Keywords: groundwater quality; spatial sampling; Mean Stratified Nonhomogeneity (MSN); Hydrogeological analysis;

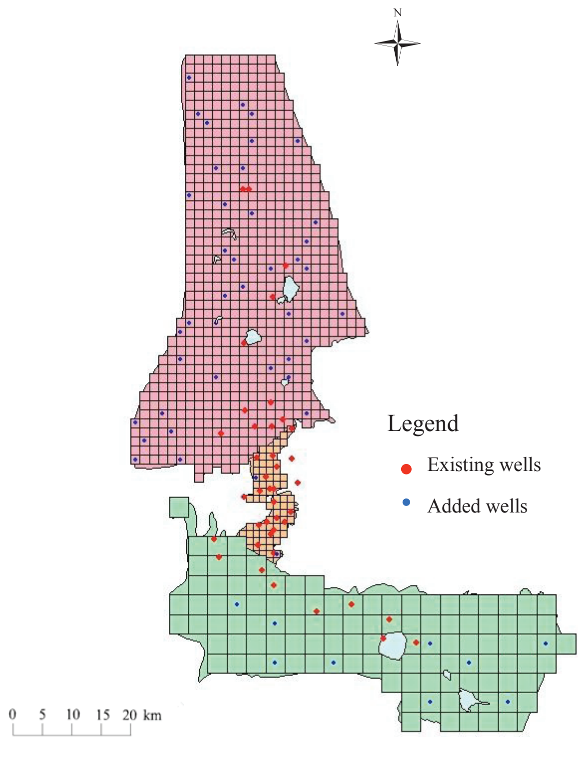

Fig.1. Distribution graph obtained by MSN

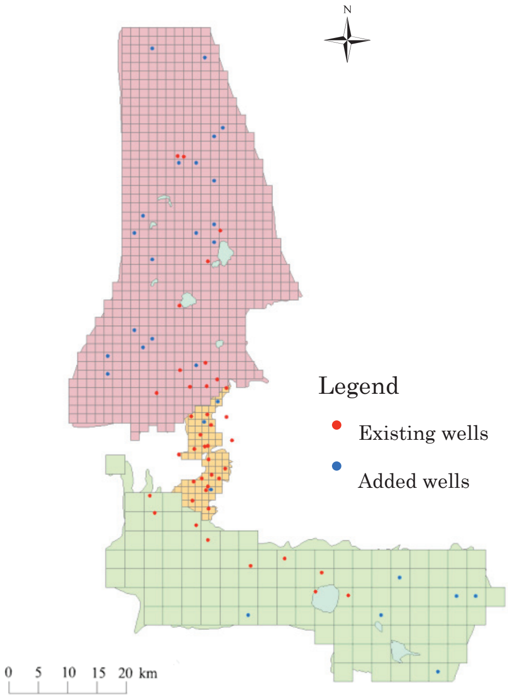

Fig.2. Distribution graph obtained from sampling

References

[1] Lindsey B.D. Hydrogeologic Framework and Sampling Design for an Assessment of Agricultural Pesticides in Ground Water in Pennsylvania. University of Michigan Library, Ann Arbor, MI.1999

[2] Wang JF, Christakos G and Hu MG, Modeling Spatial Means of Surfaces with Stratified Nonhomogeneity, *IEEE Trans on Geoscience and Remote Sensing* , 2009, **47**(12): 4167-4174

[3] Wang JF, Jiang CS, Li LF and Hu MG , *Spatial Sampling and Statistical Inference*. Science Press, Beijing China, 2009.

[4] Zhou YX and Li WP, Design of regional groundwater level monitoring networks. *Hydrogeology and Engineering Geology* 2007, **1**: 1-9.

[5]Zhou YX and Li WP. Groundwater quality monitoring and assessment. *Hydrogeology and Engineering Geology* ,2008, **1**: 1-11.